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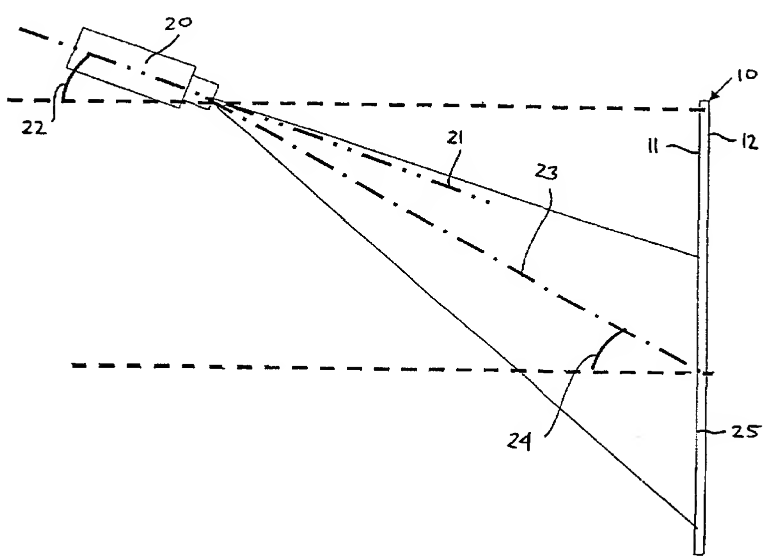
(54) Title: HOLOGRAPHIC PROJECTION SCREEN



(57) Abstract: The present invention relates to a translucent, light diffusing screen for use as a "holographic" rear projection transmission screen. According to the invention a "minimally" opaline screen serves as a holographic screen, the low degree of opacity allowing a rear-projected image to be created, the screen having a degree of transparency which under most conditions will allow the screen to be considered "invisible" by the user. More specifically, a projection screen in accordance with the invention comprises an amount less than 5g of light scattering particles per m[2] of screen projection surface.

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For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.

Title: Holographic projection screen

FIELD OF THE INVENTION

The present invention relates to a translucent, light diffusing screen for use as a transmission rear projection screen.

BACKGROUND OF THE INVENTION

In general, the concept of rear projection is to arrange an image source behind a screen which projects light forwards along a projection axis towards the screen with a view to forming an image on the front of the screen that is visible to a viewer.

If the projection screen was perfectly clear the light rays would pass through the screen unhindered and no image would be formed. In order to make the image visible to the viewer, it is necessary to incorporate a diffusion component that spreads the incoming light in order to thereby make the image visible for the viewer.

In order to provide the necessary light diffusion, traditionally two types or classes of particles have been used, either dispensed in the clear matrix material forming the screen, or as a coating thereon.

A first type of particles serves as a refractive agent, for which the refraction index deviates from the refraction index for the material in which the refractive agent is situated or dispensed, such that light entering and leaving the particles will be refracted and thereby made

visible. As follows, this type of particles is more or less translucent, allowing light to pass there through at least partially, thus being transparent or semitransparent. Typical materials used for this purpose include glass and quartz particles. In order to refract also red light, the particle size is preferably at least 1 µm. This type of light diffusion material is often used for screens which are used in combination with a rear lens element for converting the diverging light beams from the image source to parallel beams before entering the light diffusing screen thereby minimizing decline in the luminance at the edge region of the projection screen. To further control distribution of the formed image, the screen may be provided on the viewer-oriented surface thereof with a further lenticular lens system controlling the horizontal distribution of light, especially enhancing the luminance of an image throughout the viewing angle.

A different type of particles serves as a scattering agent, which means that diffusion of the incoming light primarily is produced by irregularly reflected light from the surfaces of the particles. The irregular or disordered reflections are due to both the inherent material properties of the particles as well as to their surface structure. Materials used for this purpose typically absorb most light which enters the particles and can thus be said to be substantially non-transparent or to posses only a very limited transparency. When added to a transparent screen matrix they will have an opaquing effect, resulting in an opaline or opaque whitish screen material exhibiting a milky iridescence. Typical materials used for this purpose include calcium and magnesium carbonate

as irregularly formed grains, i.e. having sand-corn like configuration. In this context it should be emphasized that also translucent, refractive particles when added to a transparent matrix to a certain degree will have an opaquing effect.

Although having essentially different basic properties, the two types of particles are often used in combination to achieve the best possible transmission of light as well as providing an image which possesses a high degree of luminance, contrast as well as correctly balanced colours. Indeed, depending on the surface configuration of the transparent particles, also these will provide a certain, small degree of light scattering, however, to the skilled person, the two types of particles can be readily identified in accordance with their general properties.

When the above-described particles, either alone or in combinations thereof, are added to a transparent matrix to provide a screen suitable for use as a rear projection screen, the resulting screen will appear to be "white" or opaline to a greater or lesser extent in ambient lighting conditions, i.e. without illumination from an imaging system. As follows from the above, the whiteness is a function of light scattering of the ambient light entering the screen.

As projection screens typically are incorporated in a projection device in front of an image source, the whiteness as such is not considered a problem when not in used, although the whiteness of an image created optically in the diffusing material will suffer from a lack of contrast. This problem is addressed by WO 00/68712

disclosing a "high contrast screen material" comprising both refractive and opaque particles.

Recently a different type of projection screen has been proposed and is generally known as "holographic" projection screens. It is to be noted that these screen when used as intended cannot be considered to provide a "true" holographic representation of an item, i.e. a "true" three-dimensional representation which will change as the viewer moves relative to the created image. In contrast, the image created on a "holographic" projection screen is a normal two-dimensional representation of an object, the term "holographic" being used merely to indicate that the projection screen is substantially fully transparent when an image is not projected thereon, and thereby "invisible" to a viewer.

Hitherto, such screens have mainly be used to catch people's eyes by creating a "magical display" in the air, for example in shops or for general advertising purposes.

A known screen of this type is the HoloPro™ marketed by G+B Pronova GmbH, Bergish Gladback, Germany and appears to correspond to the screen disclosed in WO 99/64902. More specifically, the therein-disclosed screen comprises a substantially transparent screen on a surface of which are arranged "holographic-optical" elements, i.e. a system of lens elements. These elements posses a microstructure which is substantially invisible in ambient light conditions, however, when an image is projected thereon under specified conditions (e.g. projecting angle) an image is created, however, it is only fully visible within a specified viewing angle. A similar screen is

manufactured by DNP and sold as the "ProScreen Holo Screen", however, all screen of this type have in common that they are very expensive.

SUMMARY OF THE INVENTION

Having regard to the above discussion of the prior art, the object of the present invention is to provide a projection screen suitable for use as a "holographic" screen, i.e. having a high degree of transparency when an image is not projected thereon, yet allowing a projected image to be formed thereon, which can be used under various conditions and which can be manufactured in a cost effective and efficient manner.

The present invention is based on the realisation that a holographic screen can be provided by adapting the principles embodied in the traditional projection screens, i.e. comprising light diffusing particles, and thus a departure from the hitherto used micro-lens based screens.

More specifically, the present inventor has realised that a "minimally" opaline screen can serve as a holographic screen, the degree of opacity allowing a rear-projected image to be created, the screen having a degree of transparency which under most conditions will allow the screen to be considered "invisible" by the user. Indeed, the "invisibility" is to a certain degree based on psychological effects, e.g. if an "interesting" object is placed behind the screen, the interested viewer will "over-look" a certain small degree of opacity.

Apart from allowing the screen to be produced in a cost-effective manner, the screen according to the invention is inherently insensitive to the projection angle as well as the viewing angle, this providing for easy of use as well as a high degree of visibility of the projected image, this in contrast to the lens based systems which will only function as intended within narrow angle intervals.

In a first aspect of the invention a projection screen comprises an amount of up to 5 g, preferably less than 3 g and most preferably less than 1 g, of light scattering particles per m^2 of screen projection surface distributed in the body thereof, however, depending on the type of particles, the amount may be as low as 0,1 g of light scattering particles per m^2.

Preferably, the particles are mainly in the form of substantially non-transparent particles having a grain size of less than 20 µm, preferably less than 10 µm, however, depending on the type of particles, the size may be as small as 1 µm or less. In order to provide a self-supporting screen being easy to handle, the screen body preferably has a thickness of 3-10 mm.

It is to be noted that the actual distribution of the light diffusion particles will influence both the degree of opacity as well as the experienced quality of the created image. For example, if the particles are concentrated in a relatively thin layer, as in a coating or a limited structure, a smaller amount of particles (per m^2) will provide a given opacity, however, as at the same time the image is created in a narrow plane, the individ-

ual pixels of a pixel-based image (as from an LCD projector) will be more apparent to a viewer. In contrast, a larger amount of particles will be needed to provide a given opacity when distributed throughout the matrix of the screen, however, as at the same time the particles will have a de-pixelating effect by slightly "blurring" the created image.

Therefore, depending on the requirements as to de-pixelating as well as depending on the desired manufacturing process, all or a portion of the light scattering particles may be located in a coating or a foil-sheet laminated onto the screen body. For a coating having a thickness less than 200 µm or a foil-sheet having a thickness less than 1 mm, the coating or foil-sheet comprises an amount of up to 2 g, preferably less than 1 g, of light scattering particles per m^2 of screen projection surface, the screen body comprising less than 1 g of light scattering particles per m^2.

It is well known that opaline plastic materials (such as white plastic used for carrying bags) will scatter light, mainly for light from the short wavelength range of the spectrum, i.e. the blue-green range, however, more long waved light from the red range of the spectrum has a tendency to pass directly through the plastic material. This phenomenon can be easily observed when a white plastic bag is held in front of a conventional incandescent light bulb whereby the glowing filament can be observed as a reddish spot which will blind if the light is strong.

However, by adding an amount of light refracting particles having a particle size of more than 1 µm, preferably

2-10 µm, the red light will be refracted resulting in diffusion of the light from the described glowing filament. Correspondingly, in preferred embodiment of the invention, the screen comprises up to 1 % (volume) of refractive particles with a particle size of more than 1 µm, preferably 2-10 µm.

In a second aspect the invention provides a method for establishing a "holographic" image, the method comprising the steps of arranging a projection screen in a substantially vertical position (i.e. +/- 20 degrees), arranging an image source having an optical projecting angle of 10-45 degrees relative to the horizontal plane and such that an image is projected on the screen, the screen comprising light scattering particles allowing a picture to be created corresponding to the screen, yet having a low degree of opacity, preferably as disclosed above. Preferably the screen comprises no optical lens elements on the surfaces thereof.

BRIEF DESCRIPTION OF THE DRAWINGS

In the following the invention will be further described with references to the drawings, wherein

fig. 1 shows a schematic representation of a set-up for rear-projecting an image onto a screen,

fig. 2 illustrates a Keystone compensated image as well as a non-compensated image,

fig. 3 shows an example of a preferred use situation for a holographic screen in accordance with

the invention,

fig. 4 shows a first preferred embodiment of a holographic projection screen, and

fig. 5 shows a further preferred embodiment of holographic projection screen.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

Fig. 1 shows a schematic representation of a projection screen in accordance with the invention in combination with a rear projection image source.

More specifically, a rear projection screen 10 having coplanar rear and front surfaces 11, 12 defining a general plane is arranged in a vertical position. Behind and above the screen is arranged an image source 20 (e.g. LCD projector) having an uncompensated optical projection axis 21, the image source and the axis being arranged with a tilt angle of 20 degrees with respect to horizontal, the image source being pointed towards the rear surface of the screen thereby creating a picture image. However, as the projection angle is not perpendicular to the general plane of the screen, a trapezoidal picture 30 will be created as illustrated in fig. 2. In order to compensate for this effect, the projector may be provided with a so-called Keystone correction providing a compensated, right-angled picture 31. Corresponding to the Keystone corrected picture, the resulting optical axis 23 is tilted downwardly having a larger projection angle, i.e. 35 degrees in the illustrated example.

Fig. 3 shows an example of a preferred use situation for a holographic screen in accordance with the invention. In a show or display window 50 a holographic projection screen 60 is arranged, which due to its minimal opacity will not be recognised as such by a viewer glancing at the items put on display in the window. However, when suddenly an image is projected onto the holographic screen from an image source 61 arranged behind and above the screen projecting an image corresponding to a tilted projecting axis 62 with a projection angle 63, the viewer will experience that an image is created "in the air", this providing a surprising effect. As the screen in accordance with the invention does not rely on optical lens element to achieve the holographic effect, the effective viewing angle is very broad for which reason it is not necessary that the viewer is positioned within a narrow angle in front of the screen, which means that the attention of most people passing by can be achieved. As can be seen in the figure, the high position of the image source makes it unlikely that a viewer will look directly into the filament of the image source, which allows that a screen can be used which contains substantially no light refracting particles for refracting the long waved red light.

Indeed, the holographic screen may also be used for other purposes, for example for displaying information in a public room such as in an airport.

Fig. 4 shows a first embodiment of a screen 100 according to the invention. The screen comprises a first planar surface 101 and an opposed co-planar second surface 102. The body of the screen comprises a transparent matrix ma-

terial 110 in which particles 111 are distributed. As the particles are evenly distributed in the matrix, the two surfaces can be considered to be identical, i.e. it is immaterial which side is oriented towards the image source respectively the viewer. The particles are irregularly formed grains of calcium carbonate ($CaCO_3$) having a size of less than 10 µm, preferably less than 5 µm serving primarily as light scattering agent. The calcium carbonate particles may be partly or fully replaced by particles made from $MgCO_3$, Al_2O_3, TiO_2, $BaSO_4$, ZnO, $BaCO_3$ or $Al(OH)_3$ or mixtures thereof, but preferably at least 50 % is $CaCO_3$. The body preferably has a thickness of 3-10 mm containing less than 5 g of particles per m^2 of projection surface.

In case very fine (powder-like) granules are used (such as TiO_2 used for example in white paints), even very small amounts will result in a screen having the desired properties. In a preferred embodiment, a screen comprises 0,01-0,1 g of particles per m^2 of projection surface, the particles having a size of less than 1 µm, preferably less than 0,5 µm.

Fig. 5 shows a second embodiment of a screen 200 according to the invention. The coated screen comprises a screen body 210 having a first planar surface 211 and an opposed co-planar second surface 212. The body of the screen is made from a transparent (matrix) material which in the shown embodiment comprises substantially no diffusing particles. Onto one of the surfaces is applied a coating 213 comprising diffusing particles 221 in a transparent coating-matrix 220, which preferably may be of the same type as described with reference to fig. 4.

The coating preferably has a thickness of 50-200 µm containing less than 2 g, preferably less than 1 g, of particles per m^2 of projection surface.

Instead of the coating a thin foil may be laminated onto a surface of the screen body. Such a foil preferably has a thickness of 0,1 - 1,0 mm containing less than 2 g, preferably less than 1 g, of particles per m^2 of projection surface in a transparent matrix. The composite screens may be used with either surface arranged towards the image source.

As distribution of the particles in a thin layer (as a coating or a foil) will reduce the depixilating effect, it may be desirable to add particles also to the screen body, preferably in an amount corresponding to a total amount of less than 5 g of particles per m^2 of projection surface for the coated screen.

The matrix for the screen body may be formed from any suitable transparent polymer such as polystyrene (PS), acrylics such as polymethyl methacrylate (PMMA), PET-G or a polycarbonate (PC) as well as mixtures thereof.

In order to control or enhance colour contrast, a dye may be added to the matrix, for example green, blue or grey. If it is desirable to add a light refracting agent, e.g. for compensating for the unhindered transmission of red light, an amount of light refracting particles having a particle size in the range of 1-10 µm and preferably in a concentration of less than 1 % (volume) may be added, for example as quartz or glass particles, either in granular, spherical or globular form.

EXAMPLE 1

For a screen having a surface area of 1 m^2 and a thickness of 5 mm, 5 kg of liquid PMMA having a density close to 1 g per cm^2 was prepared. To the PMMA 4,0 g of a calcium carbonate ($CaCO_3$) paste was added, the paste containing 60 % particles. According to the specification the paste contained 50 % particles having a grain size of 2,5-3,4 µm with 30-40 % having a grain size of less than 2 µm. The particle-containing PMMA was poured into a closed mould and the PMMA was allowed to harden before the particles would start to settle, the resulting screen containing 2,4 g of particles per m^2 of projection surface. The screen had a light milky appearance allowing a substantially unhindered view to items placed behind the screen, yet creating a well-defined image with good colour saturation and contrast of the LCD projector generated image.

EXAMPLE 2

For a screen having a surface area of 1 m^2 and a thickness of 1 mm, 1 kg of liquid PMMA having a density close to 1 g per cm^2 was prepared. To the PMMA 0,8 g of a calcium carbonate ($CaCO_3$) paste was added, the paste being of the same type as in example 1. The particle-containing PMMA was poured into a closed mould and the PMMA was allowed to harden before the particles would start to settle, the resulting screen containing 0,48 g of particles per m^2 of projection surface. The screen had a light milky appearance allowing a substantially unhindered view to items placed behind the screen, yet creating a well-

defined image with good colour saturation and contrast but slightly more pixelating of the LCD projector generated image. Although the second screen contained only around 20 % of the particles per m^2 of projection surface as compared to the first screen, due to the distribution in a thinner layer, the degree of opacity was not reduced correspondingly.

EXAMPLE 3

For a screen having a surface area of 1 m^2 and a thickness of 5 mm a fully transparent screen manufactured from PMMA was provided. To 100 g of a liquid acrylic lacquer 1,5 g of a calcium carbonate ($CaCO_3$) paste was added, the paste being of the same type as in example 1. The particle-containing solvent was distributed evenly over one of the screen surfaces and allowed to evaporate and harden, the resulting screen having a coating with an approximate thickness of 0,1 mm containing 0,9 g of particles per m^2 of projection surface. The screen again had a light milky appearance allowing a substantially unhindered view to items placed behind the screen, yet creating a well-defined image with good colour saturation and contrast but again slightly more pixelating of the LCD projector generated image. Although the third screen contained only around 40 % of the particles per m^2 of projection surface as compared to the first screen, due to the distribution in a thinner layer, the degree of opacity was not reduced correspondingly.

EXAMPLE 4

For a screen having a surface area of 1 m^2 and a thickness of 5 mm, 5 kg of liquid PMMA having a density close to 1 g per cm^2 was prepared. To the PMMA 0,025 g of titanium dioxide (TiO_2) powder was added. According to the specification the powder contained particles having a grain size of less than 0,2 µm and with an average grain size of 0,19 µm. The particle-containing PMMA was poured into a closed mould and the PMMA was allowed to harden before the particles would start to settle, the resulting screen containing 0,025 g of particles per m^2 of projection surface. The screen had a light milky appearance allowing a substantially unhindered view to items placed behind the screen, yet creating a well-defined image with good colour saturation and contrast of the LCD projector generated image. It was noted that the created image was very well defined when seen from lateral angles.

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Claims

1. A translucent projection screen (100) having a first surface (101) and an opposed second surface (102) substantially parallel with the first surface, the screen comprising a matrix of a transparent material and an amount of up to 5 g of light scattering particles per m^2 of screen projection surface.

2. A translucent screen according to claim 1, wherein the light scattering particles are mainly in the form of substantially non-transparent particles having a grain size of less than 20 µm, preferably less than 10 µm.

3. A translucent screen according to claim 1 or 2, wherein the amount of light scattering particles is less than 3 g, preferably less than 1 g per m^2 of screen projection surface.

4. A translucent screen according to claim 1 or 2, wherein the amount of light scattering particles is less than 1 g, preferably 0,01-0,1 g per m^2 of screen projection surface, the particles having a grain size of less than 1 µm, preferably less than 0,5 µm, most preferably less than 0,2 µm.

5. A translucent screen according to any of claims 1-4, wherein the light scattering particles are distributed substantially evenly in the matrix, the screen preferably having a thickness of 3-10 mm.

6. A translucent screen according to any claims 1-5, comprising a coating (213) on a surface thereof, the coating having a thickness of 50-200 µm containing less than 2 g, preferably less than 1 g, of particles per m^2 of projection surface, the screen matrix containing less than 1 g, preferably 0 g, of particles per m^2 of projection surface.

7. A translucent screen according to any claims 1-6, comprising a foil on a surface thereof, the foil having a thickness of 0,1-1,0 mm containing less than 2 g, preferably less than 1 g, of particles per m^2 of projection surface, the screen matrix containing less than 1 g, preferably 0 g, of particles per m^2 of projection surface.

8. A translucent screen according to any of the previous claims, wherein the light scattering particles comprise one or more materials from the group consisting of $CaCO_3$, $MgCO_3$ Al_2O_3, TiO_2, $BaSO_4$, ZnO, $BaCO_3$ or $Al(OH)_3$, and wherein the matrix comprises PS, PMMA, PETG, PC or a mixture thereof.

9. A translucent screen according to any of the previous claims, wherein the screen comprises up to 1 volume-% of refractive particles with a particle size of more than 1 µm, preferably 2-10 µm.

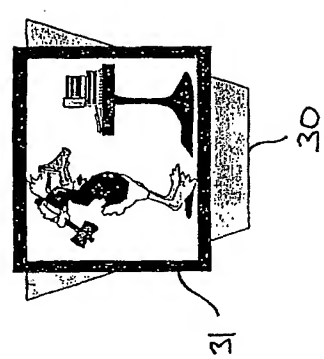
10. A method for establishing a projected image, the method comprising the steps of:

- arranging a projection screen (10) as defined in any of the previous claims in a position in the range of +/- 20 degrees relative to vertical,

- arranging an image source (20) having an optical projecting angle (23) of 10-45 degrees relative to a horizontal plane such that an image can be projected on the screen corresponding to a projection surface area,
- the screen comprising light diffusing particles allowing a picture to be created corresponding to the projection surface area of the screen, yet having a low degree of opacity allowing a viewer a substantially unhindered view to an object arranged behind the screen when no image is formed on the screen.

11. A method for establishing a projected image, the method comprising the steps of:
- arranging a projection screen in a position in the range of +/- 20 degrees relative to vertical,
- arranging an image source having an optical projecting angle of 10-45 degrees relative to a horizontal plane such that an image can be projected on the screen corresponding to a projection surface area,
- the screen comprising light diffusing particles allowing a picture to be created corresponding to the projection surface area, yet having a low degree of opacity allowing a viewer a substantially unhindered view to an object arranged behind the screen when no image is formed on the screen, wherein
- the screen comprises no optical lens elements on the projection surface area thereof.

Fig. 2



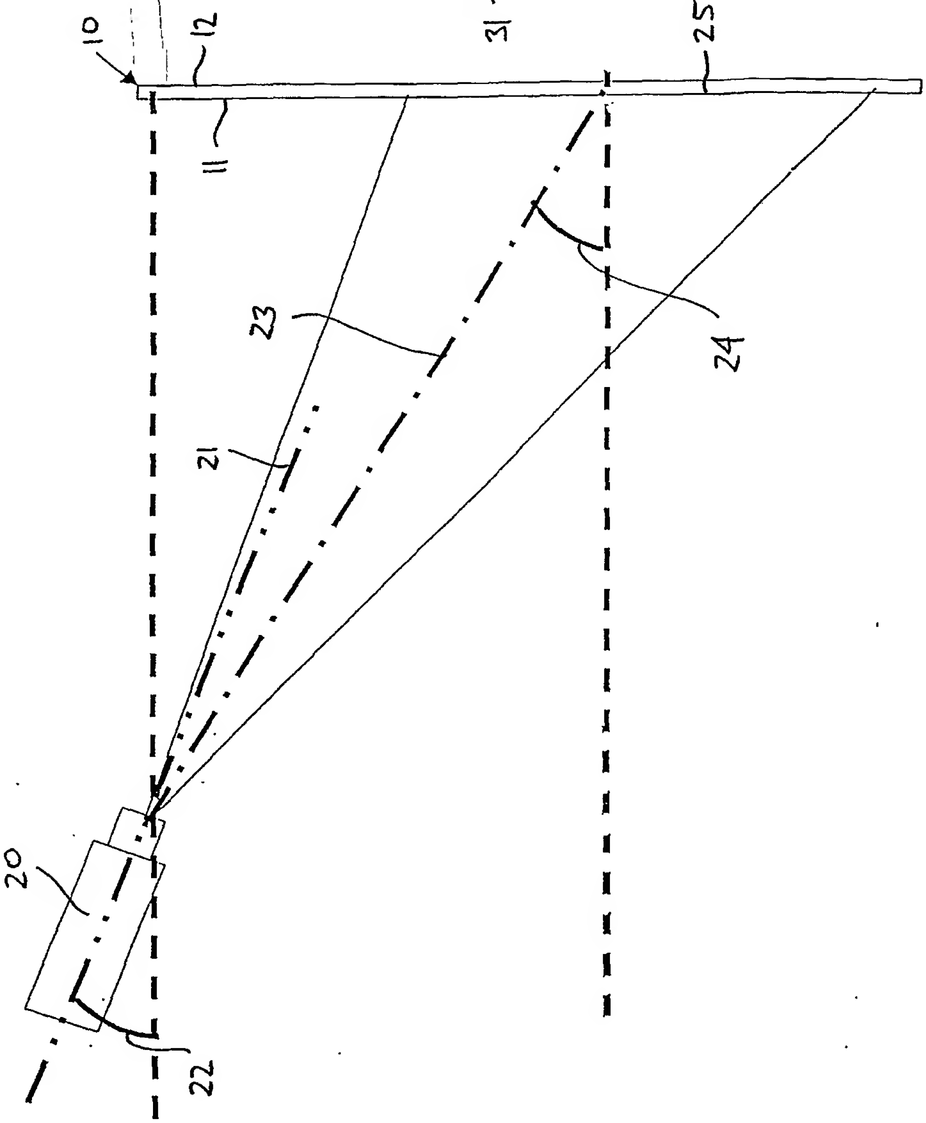


Fig. 1

Fig. 3

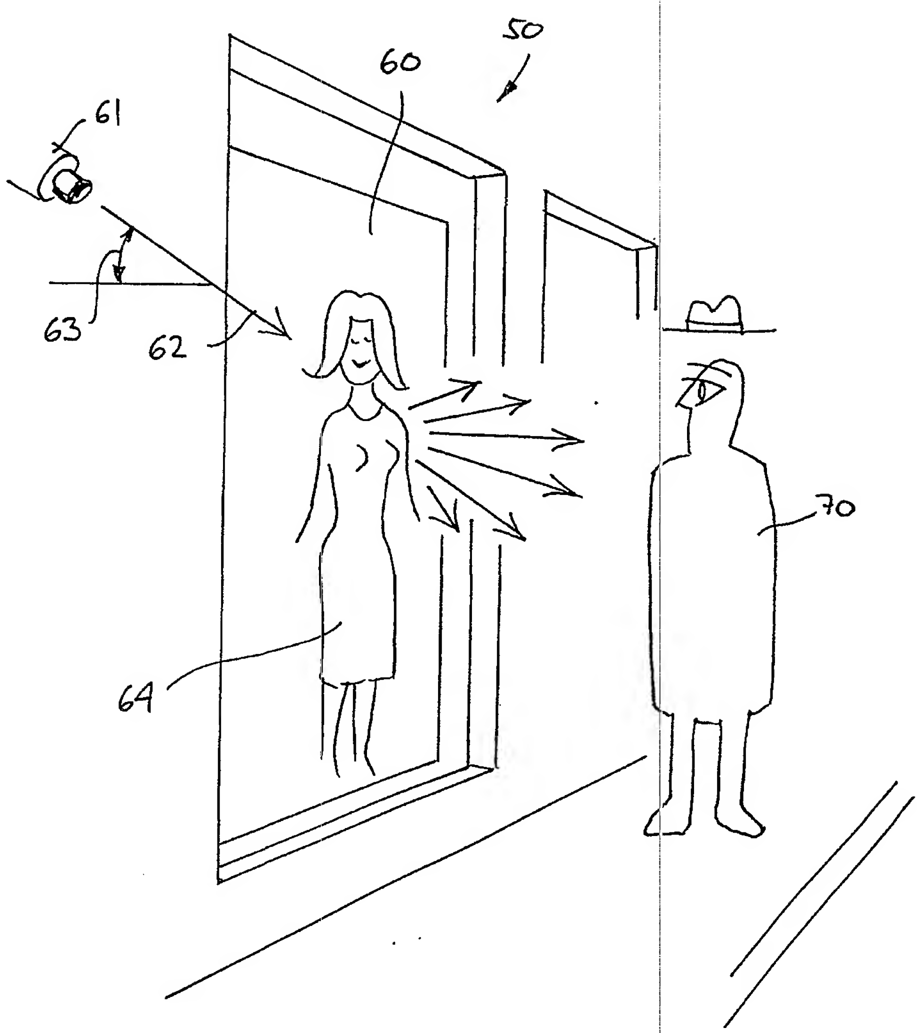


Fig. 4

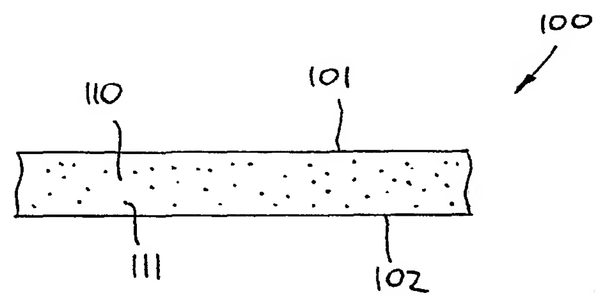
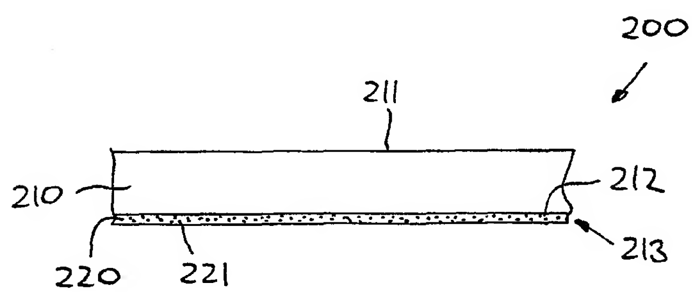


Fig. 5



INTERNATIONAL SEARCH REPORT

International application No.
PCT/DK 01/00769

A. CLASSIFICATION OF SUBJECT MATTER

IPC7: G03B 21/62

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC7: G03B

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

WPI, PAJ

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	JP 4-324848 A (..), 13 November 1992 (13.11.92) --	1-11
A	US 3751135 A (E. CLAUSEN ET AL), 7 August 1973 (07.08.73) --	1-11
A	EP 0561551 A1 (ROHM AND HAAS COMPANY), 22 Sept 1993 (22.09.93) --	1-11
A	EP 0464499 A2 (SUMITOMO CHEMICAL COMPANY, LIMITED), 8 January 1992 (08.01.92) --	1-11

[X] Further documents are listed in the continuation of Box C. [X] See patent family annex.

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Date of the actual completion of the international search	Date of mailing of the international search report
1 March 2002	22.03.02
Name and mailing address of the ISA/ European Patent Office Facsimile No.	Authorized officer Björn Kallstenius / MRo Telephone No.

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
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INTERNATIONAL SEARCH REPORT

Information on patent family members

28/01/02

I . application No.
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